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(54) Doctor blade

(57) A doctor blade for application and smoothing of a coating on a running paper web, wherein the entry zone (9) of the blade (1) intended for engagement with the web, and at least a part (4a) of the bevel surface (4) downstream of said zone in the direction of travel (6) of the web (7), as well as a part (5c) of the entry side (2) of the blade (1) upstream of the entry zone (9), are provided with a thin, wear-resistant surface coating (5). The coating 5 has preferably a total thickness of 0.25 mm or less and consists of ceramic material, metal oxides or metal carbides. The coating 5 is preferably applied as a series of superimposed thin layers, each applied by spraying the coating material in a molten state.

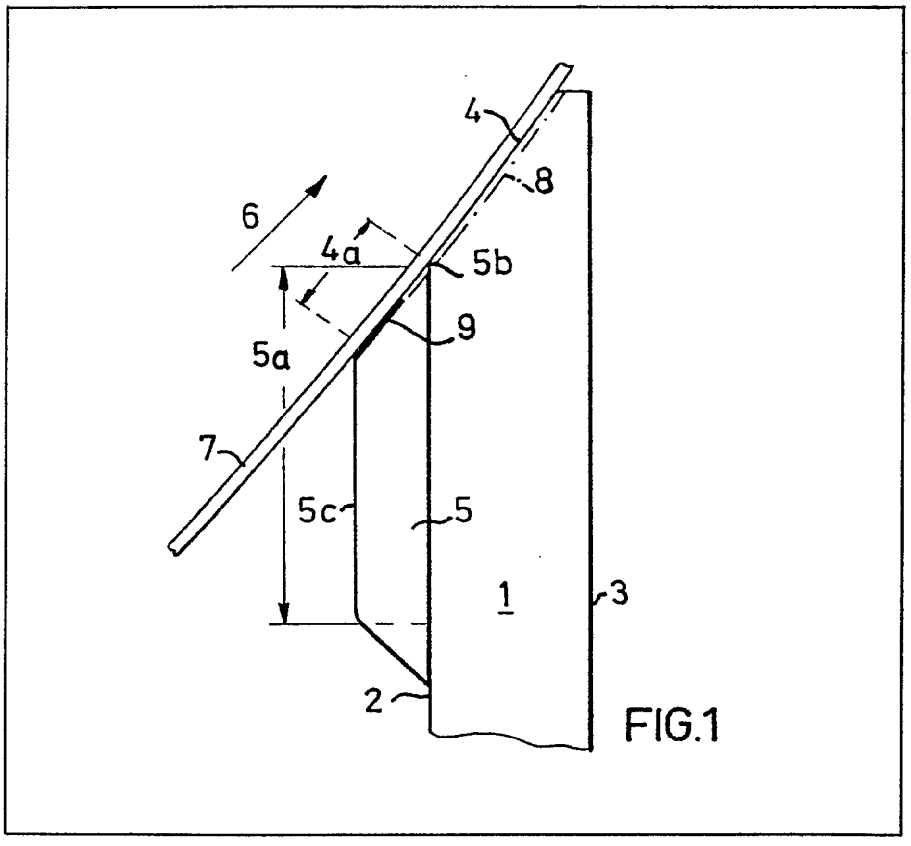

FIG.1

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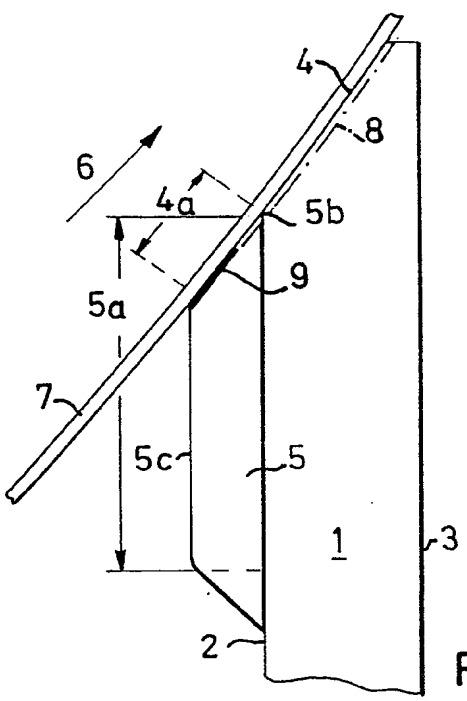

FIG.1

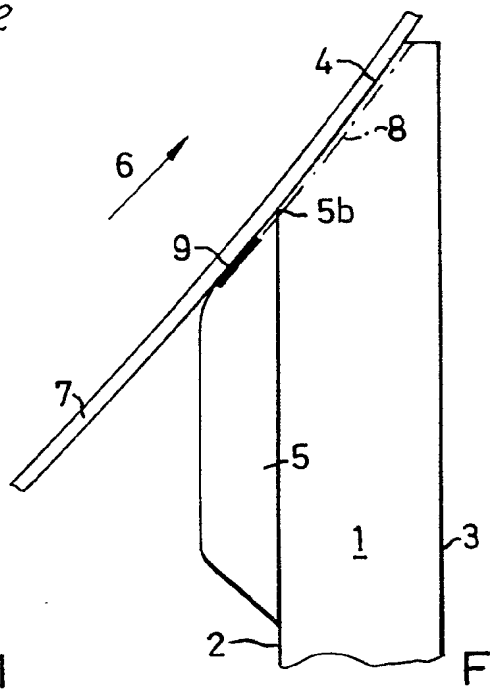

FIG.2

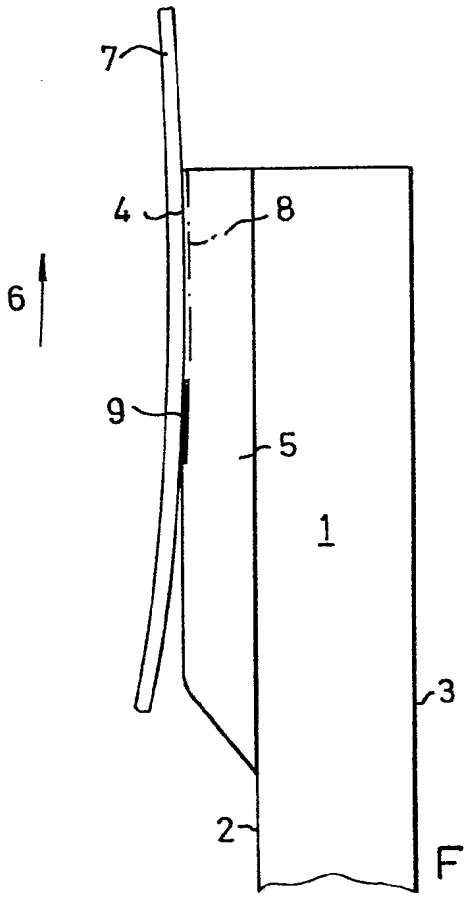

FIG. 3

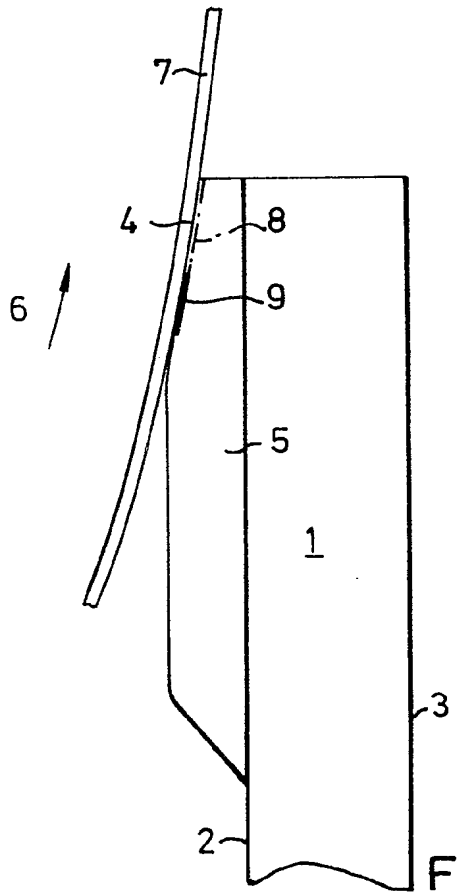

FIG.4

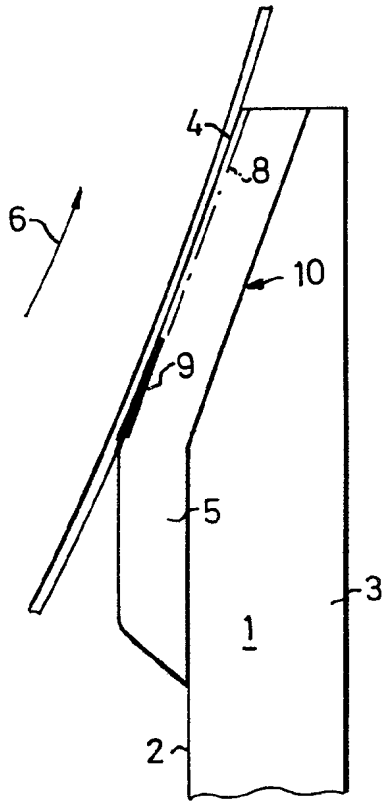

FIG.5

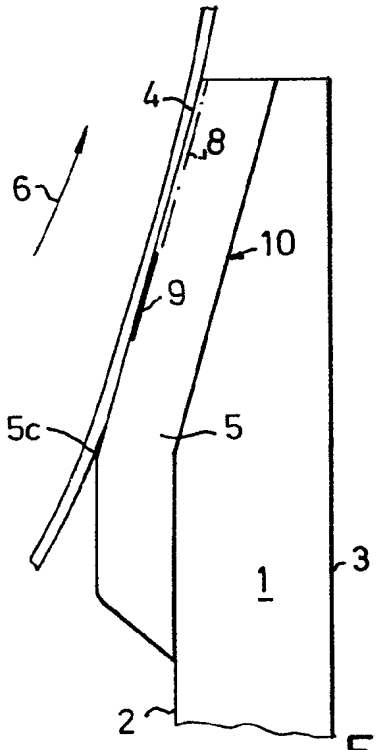

FIG.6

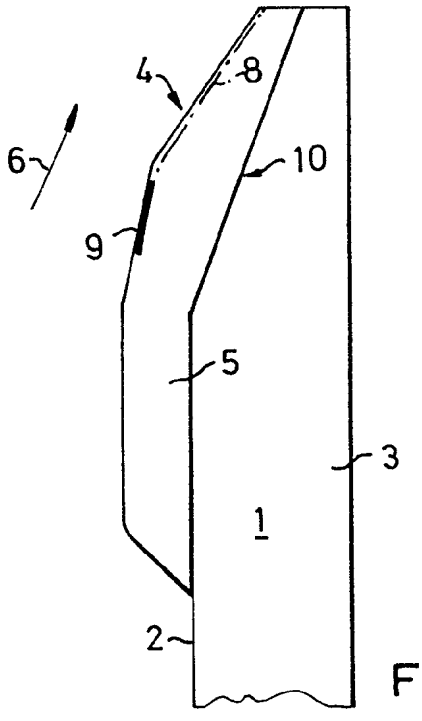

FIG.7

SPECIFICATION
Doctor blade

The present invention relates to a doctor blade for controlled application and smoothing of a coating composition on a continuously moving paper web.

Developments in paper-coating technology tend towards coating plants with higher and higher production rates. Plants exist today with paper web speeds of up to 1500 m/min. and more, the width of the paper web sometimes being as much as 8 meters or more. Such plants demand great precision of the doctor used for such coating, particularly since the quantity of coating composition applied is usually not more than 5—25 g/m^2 paper surface. In this field it is important that the layer of coating composition on the paper web must be perfectly uniform.

The coating result of such a coating plant is affected to a great extent by the length of the blade bevel in the direction of travel of the web in relation to the spring force applied on the flexible blade. The surface pressure applied, i.e. the pressure per unit surface area exerted via the bevel on the surface of the paper, known as the specific surface pressure, has decisive significance for the quantity of coating composition remaining on the web. A specific ratio therefore prevails between the extent of the bevel and the yielding properties of the blade. To prevent changes in the extent of the bevel surface due to wear during the coating process, therefore, such coating blades are now normally pre-ground to ensure a bevel extent and bevel angle which correspond as closely as possible to the actual conditions prevailing during the coating process itself. It is also important that the flexibility of the blade is adjusted to the prevailing spring force so that the blade will adjust to any uneveness in the web and also allow through defects such as lumps or thicker patches in the paper web.

Conventional doctor blades do give a good coating result, but they have the drawback of being subject to rapid and uneven wear and must therefore be replaced after only a small part of the blade material has become worn. This is because, for practical reasons, the coating blade, which generally cooperates with one side of the coated paper web and a rubber-clad support roller carrying the other side of the paper web, is wider than the paper web. Furthermore, pigment dispersions of clay in water are usually used for coating paper, which means that both the coating composition and the paper web itself have an extremely abrasive effect on the edge of the blade. On the other hand, those parts of the blades located beyond the paper web and thus merely in contact with the rubber-clad support roller during the coating process, are subjected to negligible wear. This means that the edge of the blade, initially straight, will become worn and somewhat concave along the sections where the paper web runs and after a while the coating across the web will become uneven. In practice, therefore, conventional blades must be replaced after only a few hours running. This is expensive, not only from the material point of view, but also because it incurs expensive shut-downs followed by new running-in periods.

A great deal of work has been put into endeavours to increase the service life of conventional coating blades and the properties of the traditional blade have been optimized by a suitable choice of steel composition and by treatments such as annealing.

In theory, it might be possible to increase the service life of such a coating blade by using a blade material which in itself is more wear-resistant than the conventional spring-steel. Materials apparently suitable, such as hard metals and cermets, are not always sufficiently flexible. Indeed such materials are often extremely brittle and would therefore break easily due to the stresses normally occurring from time to time in use of a doctor blade.

In technical fields other than coating, attempts have previously been made to solve wear problems by attaching pieces or strips of more wear-resistant material to the carrier material used. Hard chromium plating or plating with some other metal has also been suggested as a means of giving inherently soft carrier materials a better wearing surface. Extensive experiments carried out to solve the problem of wear in doctor blades in similar ways have been unsuccessful with the thin coating blades used in paper manufacture. These known solutions proved difficult to implement from the technical point of view with the thin blade material used and it was also found that the desirable properties of the thin basic blade material, such as flexibility, necessary for good coating results, were considerably detracted from by the measures adopted to improve wear-resistance. It is, of course, essential that a coating blade having an improved wear resistance as compared with conventional blades should have not only a longer service life, but still give a perfectly satisfactory coating result, if it is to be adopted.

An object of the present invention is to provide an improved doctor blade for the purpose specified which is capable of providing satisfactory coating performance as well as having an extended service life as compared with conventional blades.

According to this invention there is provided a doctor blade for controlled application and smoothing of a coating composition on a running paper web, said blade consisting of a flexible steel strip in which an operative zone of the blade is provided with a surface coating, thin relative to the strip thickness, having higher wear resistance than the steel blade.

In a preferred embodiment of the invention, the wear-resistant coating is built up step-wise on the blade by applying successively, one on top of the other, a plurality of thin layers of said wear-resistant material, the material being supplied by spraying it in a molten state.

Embodiments of the invention are described below by way of example with reference to the accompanying drawings, in which:

FIGURES 1 to 8 are diagrammatic side views illustrating respective different embodiments of the invention.

The doctor blades shown in the drawings are intended for use in coating moving paper webs. In such a coating process the paper web is generally caused to partially surround a rubber-clad support roller, rotating in the direction of travel of the web. By means of a rotating application roller, partly immersed in a sump of coating composition, an excess of coating composition is applied on one side of the paper web and a doctor blade, arranged in principle in a blade-holder of conventional type, is pressed against the surface of the web coated in this way, so as to smooth out the layer of coating composition applied. The contact angle of the blade against the web, and the pressure with which the blade bears against the web are preferably adjustable, and appropriate adjustment of the contact pressure and the contact angle of the blade against the paper web allows the amount of coating composition remaining on the web to be determined with great precision. The doctor blade shown in the drawings are used in the same way as conventional doctor blades in such a process.

Only the operative free end of the respective doctor blade is shown in each of Figures 1 to 8. In each of the embodiments to which these figures relate, the doctor blade comprises a strip of steel carrier material, having parallel opposite major faces 2 and 3. Each of the blades shown has a working surface 4 over which, in use, it engages the paper web. The extent of the surface 4 is indicated in the drawings by a broken line 8 and also includes part of an entry zone 9 indicated by a thick, unbroken line, which is the zone where, in use, one side of a paper web 7, travelling in the direction of the arrow 6, first comes into contact with the blade. The other side of the paper web generally engages a support roller, not shown, rotating in the direction of the arrow 6, although in some arrangements the web is not necessarily supported by such a roller over the whole of its zone of engagement with the doctor blade. The part of the flat surface 2 facing the paper web 7 has a thin coating 5 of more wear resistant material than the blade material 1. The composition and structure of the coating 5 are discussed in more detail below. The working surface of each doctor blade is thus designed to cooperate in use with the paper web via a layer of papercoating composition, not shown for the sake of simplicity, between the web and said working surface. The coating 5 is thus applied on the flat surface 2 of the blade 1 which first meets the paper web and faces the roller. The flat surface 2 is also in the following termed the entry side of the blade. The blade coating 5 is confined to a coating zone, the width of which along the entry side 2 is preferably at most 20 mm. In Figure 1, the coating zone is designated 5*a*.

In the embodiments of Figures 1, 2 and 4 to 6, the working surface 4 is provided by a bevel surface which extends from a free edge face of the blade to a portion, parallel with the face 2, of the surface of the coating 5 on the face 2 and inclined slightly, at an obtuse angle relative to the face 2.

In the following description of these embodiments, the working surface is also referred to as the bevel 4.

In the embodiment of Figure 8, the working surface 4 is provided by a slightly concave surface extending obliquely relative to the faces 2 and 3, from the surface of the coating 5 on face 2 to the coating 5 on face 3, the work surface 4 in this embodiment thus forming the edge face of the blade.

In the arrangements of Figures 1, 2 and 8, the surface 4 intersects the carrier material and thus, in these embodiments, the total working surface includes both a part 4a provided by the coating 5 and a part deriving from the strip. In Figure 1, the bevel part 4a is thus in the same plane as the remainder of the bevel surface 4 and includes the entry zone 9 and the tip 5b of the coating 5 closest the free edge of the blank. Reference 5b denotes the flat surface of the blade coating 5 parallel with face 2, upstream of the entry zone 9.

Figure 2 shows a variant of the blade shown in Figure 1, in which the coating 5 upstream upstream of and/or within the entry zone 9 is suitably rounded. This rounding can be achieved, for instance, by suitable aftergrinding of the coating.

In the embodiment of the invention shown in Figures 3 to 7 the entire working surface of the blade is provided by the wear-resistant coating.

Figure 3 shows a so-called trailing blade, in which the working surface is provided by the surface, substantially parallel with the face 2, of the coating 5 on face 2.

Figure 4 shows a variant of the blade shown in Figure 3, in which the entry zone 9 and adjoining remainder of surface 4 are provided by a bevel surface which does not, however, intersect the carrier material and which has been formed by grinding angularly a section of the coating 5. The transition in the coating from entry side 5c to entry zone 9 is preferably rounded in the embodiments of Figures 1, 2, 4 to 6 and 8.

In the embodiments of Figures 5, 6, and 7 the wear-resistant coating 5 on the entry side 2 of the blade has been deposited on a bevel surface 10 previously formed on the strip 1 and extending from the face 2 to the free edge of the strip 1.

In the embodiment in Figure 6 the surface 5c of the coating 5 upstream of the transition to the entry zone 9 has been given a suitable convex form by after-grinding the coating.

In the embodiment of Figure 7, the working surface 4, provided entirely by the coating 5, has been given an approximately rounded form by means of step-wise grinding, to provide a surface portion, upstream of entry zone 9, parallel with face 2, a slightly inclined surface portion, including entry zone 9, and a more inclined surface portion

downstream of entry zone 9. Thus, within the scope of the invention, the bevel surface 4 can be after-ground to give a suitable surface for any specific purpose.

In the embodiment of Figure 8 the working surface 4 comprises an entry part 4a, an exit part 4b and a central part 4c lying between said entry part 4a and said exit part 4b. The entry part 4a and exit part 4b are provided by the wear-resistant material, whereas the central part 4c consists of the uncoated carrier blade material.

The blade of Figure 8 is preferably manufactured by applying a wear-resistant coating on opposite flat surfaces a strip of the carrier material in the form of a band, whereafter the band is cut longitudinally along the coated regions and the cut edge ground to provide the oblique working surface 4.

The carrier material of the blade, in each of the embodiments described, suitably consists of a steel strip having a thickness of 0.10—0.70 mm and a hardness of at least 22 Rockwell C. The strip material is usually a surface-tempered carbon steel of spring steel type with the following composition, for instance:

C	1.02%
Si	0.20%
Mn	0.40%
P_{max}	0.03%
S_{max}	0.025%

The blade material used is thus manufactured from the above-mentioned cold-rolled, toughened, steel strip and is nowadays generally available in standard sizes such as 0.254, 0.305 or 0.381 mm.

For most purposes, the coating 5 should have a maximum thickness of, 0.25 mm and a minimum total thickness of 0.02 mm. The coating is built up of several thin layers applied one on top of the other in succession by spraying the wear resistant material in a molten state, each thin layer in this case having a thickness of 0.002—0.030 mm, for instance. In some cases, however, especially if the coating zone on the blade is not too wide, it is possible to obtain an extremely high wear-resistance by applying a somewhat thicker coating having a total thickness of about 0.35 mm.

More particularly, each thin layer is applied by a thermal spraying technique in which the molten coating material is sprayed against the surface to be coated. In the present case plasma or flame spraying are suitable methods. With plasma-spraying, preferable in many cases, a gas is heated so intensely by an arc that the gas achieves plasma state. In this plasma state the gas is sprayed from a nozzle in a jet and the material to be used for coating is supplied to the plasma jet in powder form by a carrier gas. The powder thus melts immediately and is thrown by the jet in molten state onto the surface to be coated. To avoid heat-damage on the extremely thin steel strip being coated, the coating, very thin in itself, is built up in steps and allowed or caused to cool after each step.

Even with the wear-resistant coating, preferred embodiments of doctor blade proposed according to the invention have substantially the same flexibility as the original, uncoated steel blade, and a perfectly satisfactory coating result is thus guaranteed. The step-wise building up of the very thin surface coating as proposed, ensures good flexibility and minimum brittleness in the coating layer itself.

To achieve a coating having the finest quality with respect to uniformity of web-coating, the blade-coating before and/or within the entry zone and possibly also in the subsequent bevel surface, is formed by a bevelled or convexly rounded surface. By this is meant that the blade-coating in these regions may be given a curved form without sharp edges, this being suitably achieved by equivalent post-grinding of the coating in steps.

As to the structure of the wear-resistant surface coating, before the first thin layer is applied on the carrier material, the carrier material should be subjected, within the surface zone to be coated, to a suitable preparatory surface treatment such as gentle blasting with carborundum, preferably immediately prior to application of the first thin layer. In some cases it may be appropriate to apply a layer of binder, e.g. nickel alloy or the like, between the pretreated surface of the carrier material and the first layer. The various thin layers are then applied successively in such a way as not to affect the original flexibility and smoothness of the strip.

Finally, the finished surface coating may, if desired, be subjected to grinding to produce a grinding finish less than 3,0 u R_a.

The wear-resistant material used in the coating according to the invention may consist of cermets, one or more metal oxides or one or more metal carbides or combinations of these. The wear-resistant coating material most suitable for any particular purpose may, of course, have to be selected taking into account, for instance, the quality of paper-coating desired in individual cases. Although certain coating materials, such as chromium oxide, offer good wear resistance, it has been noted that such a coating may after some time in use result in a slight deterioration in the coating. However, this deterioration is negligible for most commercial coating purposes.

Surprisingly blade-coatings consisting primarily of alumina have proved to be particularly suitable for high-quality web-coating required for some purposes. Particularly good results have been achieved using blade-coatings of alumina (Al_2O_3) with a small quantity of some other metal oxide, such as titanium oxide (TiO_2).

The following experiments with doctor blades embodying the invention confirm the desired improvement over a conventional blades.

Experiment 1

A blade embodying the invention, with a wear-resistant surface coating of alumina and titanium oxide was used for coating a wood-free printing paper. The web speed was 500 m/min and the coating composition used was a water dispersion of 20% kaolin and 80% calcium carbonate.

The blade could be used for 30 hours with a good coating result.

A conventional coating blade without a wear resistant coating, used under equivalent conditions, had to be changed after 4 hours running.

Experiment 2

A blade embodying the invention, with a wear-resistant coating of alumina, was used for coating a wood-free paper with a coating composition based on a water dispersion of pigment. The web speed was 400 m/min. The blade gave a perfectly satisfactory coating result over a period of 60 hours.

A control experiment using a conventional blade without a wear-resistant coating showed that this conventional blade must be replaced after a running time of 8 hours.

Experiment 3

Experiment 2 above was repeated with a blade embodying the invention having a coating of chromium oxide. From the point of view of wear, this blade could be used for considerably longer than 60 hours.

However, after only a few hours running, the coating result was slightly poorer, but probably fully acceptable for most purposes.

As mentioned earlier, the width of the wear-resistant coating layer should not exceed 20 mm. In practice the coating layer should be as narrow as possible to minimise material consumption and to eliminate the risk of cracks in the layer when the carrier material moves. A wear-resistant coating width less than 10 mm is therefore to be preferred in practice.

The blades described with reference to the drawings have various advantages. The application of a relatively thin, durable surface coating on only a small part of the coating blade enables the blade to retain the necessary flexibility and other properties of the carrier material. The extreme thinness of the surface coating minimizes brittleness and the risk of cracks in the wear-resistant coating. This, combined with the fact that such a blade has the same flexibility as a traditional blade enables such blades to be used directly in conventional blade-holders on existing paper-coating machines.

The preferred method of applying the wear-resistant coating is that described in our co-pending Application No. , to which reference should be made.

CLAIMS

1. A doctor blade for controlled application and smoothing of a coating composition on a running paper web, said blade consisting of a flexible steel strip in which an operative zone of the blade is provided with a surface coating, thin relative to the strip thickness, having higher wear resistance than the steel blade.

2. A doctor blade according to claim 1 wherein said flexible steel strip has a thickness of 0.7 mm or less and wherein said coating has a total thickness of at most 0.25 mm.

3. A doctor blade according to claim 1 or claim 2 wherein said strip has generally parallel opposite major surfaces, the blade including a bevel surface inclined obtusely with respect to one of said major surfaces of the strip, and inclined acutely with respect to the other of said major surfaces, said bevel surface affording said operative zone of the blade, said operative zone being disposed in the region of the upstream part of said bevel surface near its junction with said one major face and including an entry zone, a zone upstream of and adjoining the entry zone, and a zone downstream of and adjoining the entry zone.

4. A doctor blade according to any one of claims 1 to 3, wherein said coating comprises a ceramic material.

5. A doctor blade according to any of claims 1 to 3 wherein said coating comprises at least one metal oxide.

6. A doctor blade according to any of claims 1 to 3 wherein said coating comprises at least one metal carbide.

7. A doctor blade according to any of claims 1 to 3, in which the wear-resistant coating consists substantially of alumina.

8. A doctor blade according to any of claims 1 to 3, in which the wear-resistant coating consists of alumina with a small quantity of some other metal oxide.

9. A doctor blade according to claim 8 wherein said other metal oxide is titanium oxide.

10. A doctor blade according to claim 9, in which the wear-resistant coating contains 97% Al_2O_3 and 3% TiO_2.

11. A doctor blade according claim 1, in which the surface provided by said coating includes a face affording said entry zone, a relatively inclined face upstream of the entry zone and a relatively inclined face downstream of the entry zone.

12. A doctor blade according to any preceding claim, in which the wear-resistant surface coating comprises several layers of said wear-resistant material applied one on top of the other in successive steps in a molten state, by spraying.

13. A doctor blade according to claim 3, in which the entire bevel surface of the blade is provided by said wear-resistant coating.

14. A doctor blade according to claim 3, in which the bevel surface further includes an exit zone in the region of the junction of the bevel surface with said other of the major surfaces of the blade, and an intermediate central zone, said entry zone and said exit zone being provided by respective said wear-resistant coatings whereas said central zone is uncoated.

15. A doctor blade according to claim 1, in

which the total thickness of the wear-resistant coating is not more than 0.35 mm.

16. A doctor blade according to claim 1, in which the total thickness of the wear-resistant coating is not more than 0.25 mm.

17. A doctor blade according to claim 3, in which the surface provided by said wear-resistant coating is bevelled or rounded upstream of/or within the entry zone.

18. A doctor blade according to claim 3, wherein said steel strip has a major surface, an edge face and a bevel surface extending between said major surface and said edge face, and wherein said bevel surface of the strip is entirely coated with said wear resistant material, and the coating extending over said bevel surface of the strip affords said bevel surface of the doctor blade.

19. A doctor blade according to any preceding claim in which said operative zone is provided on one side of the blade adjacent an edge thereof, and the width of the zone, on said side of the blade, on which said coating is deposited, is at most 20 mm.

20. A doctor blade substantially as hereinbefore described with reference to, and as shown in, Figure 1 of the accompanying drawings.

21. A doctor blade substantially as hereinbefore described with reference to, and as shown in, Figure 2 of the accompanying drawings.

22. A doctor blade substantially as hereinbefore described with reference to, and as shown in, Figure 3 of the accompanying drawings.

23. A doctor blade as hereinbefore described with reference to Figure 4 of, and as shown in, the accompanying drawings.

24. A doctor blade substantially as hereinbefore described with reference to, and as shown in, Figure 5 of the accompanying drawings.

25. A doctor blade substantially as hereinbefore described with reference to, and as shown in, Figure 6 of the accompanying drawings.

26. A doctor blade substantially as hereinbefore described with reference to, and as shown in, Figure 7 of the accompanying drawings.

27. Any novel feature or combination of features described herein.

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